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FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)
L9289.01148	09/868699

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/JP00/07263	October 19, 2000	October 21, 1999

TITLE OF INVENTION

ARRAY ANTENNA RADIO COMMUNICATION APPARATUS AND WEIGHT COEFFICIENT GENERATING METHOD

APPLICANT(S) FOR DO/EO/US

Takahisa AOYAMA

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☐ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☐ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

Claim for Priority with PCT/IB/304
PCT/IB/308
PCT/RO/101

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/868699	PCT/JP00/07263	L9289.01148

24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		**CALCULATIONS** PTO USE ONLY
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	**$1000.00**	
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	**$860.00**	
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	**$710.00**	
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	**$690.00**	
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	**$100.00**	
ENTER APPROPRIATE BASIC FEE AMOUNT =		**$860.00**
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).		**$0.00**

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	9 - 20 =	0	x $18.00	**$0.00**
Independent claims	3 - 3 =	0	x $80.00	**$0.00**
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**
TOTAL OF ABOVE CALCULATIONS =				**$860.00**
☐ Applicant claims small entity status. (See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				**$0.00**
SUBTOTAL =				**$860.00**
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**
TOTAL NATIONAL FEE =				**$860.00**
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☒				**$40.00**
TOTAL FEES ENCLOSED =				**$900.00**
				Amount to be: refunded $
				charged $

a. ☒ A check in the amount of **$900.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **19-4375** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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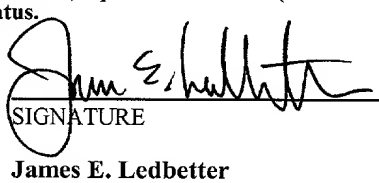

SIGNATURE

James E. Ledbetter
NAME

28,732
REGISTRATION NUMBER

June 20, 2001
DATE

4/PRTS

09/868699

JC18 Rec'd PCT/PTO 2 0 JUN 2001

DESCRIPTION

ARRAY ANTENNA RADIO COMMUNICATION APPARATUS AND WEIGHT COEFFICIENT GENERATING METHOD

Technical Field

The present invention relates to an array antenna radio communication apparatus and a weight coefficient generating method.

Background Art

An array antenna radio communication apparatus is a radio communication apparatus that comprises a plurality of antennas and is capable of setting directivity freely by making an adjustment of each of amplitude and a phase to signals received via the respective antennas. The adjustments of amplitude and the phase to a received signal is carried out by multiplying the received signal by weight coefficient (hereinafter referred to as "weight").

The array antenna radio communication apparatus adjusts weights to multiply, making it possible to receive only a signal incoming from a desired direction intensively. It is thereby possible for the array antenna radio communication apparatus to maintain a reception SIR (Signal to Interface Ratio) on the signal incoming from the desired direction.

The conventional array antenna radio communication apparatus, however, has the following

problems when it is applied to a mobile communication base station apparatus (hereinafter referred to "base station") used in a CDMA radio communication system.

More specifically, in the CDMA radio communication system, communication between the base station and each mobile communication terminal apparatus (hereinafter referred to as "mobile station") is performed in such a way that a different spread code is assigned to each mobile station and the same frequency band is used at each mobile station.

In the case where a mobile station that transmits signals having high reception power in the base station and a mobile station that transmits signals having low reception power in the base station exist, the signals having high reception power cause interference with signals having low reception power since communications are performed using the same frequency band. For this reason, the base station cannot maintain the reception SIR of signals having low reception power high, with the result that the base station cannot find out the direction where the mobile station that transmits signals having low reception power exists.

Accordingly, this causes a problem in which the base station can form directivity to the mobile station that transmits signals having high reception

power but cannot form directivity to the mobile station that transmits signals having low reception power.

Further, in the case where the base station cannot form directivity to the mobile station that transmits signals having low reception power, the base station transmits signals in all directions when transmitting signals to the mobile station that transmits signals having low reception power. This causes a problem in which the signals, which are sent to the mobile station that transmits signals with low reception power, result in interference signals with other mobile stations.

Furthermore, in the base station that performs weight control using an algorithm of MMSE (Minimum Mean Square Error) standard, the signals with low reception power do not occur interference with the signals with high reception power in some instances. In this case, the base station can maintain reception SIR of signals with high reception power sufficiently high without forming directivity to the mobile station that transmits signals with high reception power. Namely, the base station does not form directivity to the mobile station that transmits signals with high reception power. In the case where the base station does not form directivity to the mobile station that transmits signals with high reception power, the base station transmits signals

in all directions when transmitting signals to the mobile station that transmits signals with high reception power. Hence, this causes a problem in which the signals, which are sent to the mobile station that transmits signals with high reception power, result in interference signals with other mobile stations.

Disclosure of Invention

It is an object of the present invention is to provide an array antenna radio communication apparatus capable of forming directivity with an excellent convergence to a mobile station to which the directivity is not formed yet, and relates to a weight coefficient generating method.

The inventor of the present invention has found out that reception weights and radiation patterns can be formed to the mobile station to which the directivity is not formed yet by use of the radiation patterns formed to the other mobile station.

Namely, in order to achieve the above object, the present invention detects a null point of the radiation pattern formed to the other mobile station and estimates the direction where the other mobile station exists based on the null point, whereby forming a radiation pattern to the mobile station to which the directivity is not formed yet.

Brief Description of Drawings

FIG. 1 is a block diagram of main parts illustrating a general configuration of an array antenna radio communication apparatus according to the first embodiment of the present invention;

FIG. 2A is a view illustrating a state that radiation patterns are formed by the array antenna radio communication apparatus according to the first embodiment of the present invention;

FIG. 2B is a view illustrating a state that radiation patterns are formed by the array antenna radio communication apparatus according to the second embodiment of the present invention;

FIG. 3 is a block diagram of main parts illustrating a general configuration of an array antenna radio communication apparatus according to the second embodiment of the present invention; and

FIG. 4 is a block diagram of main parts illustrating a general configuration of an array antenna radio communication apparatus according to the third embodiment of the present invention.

Best Mode for Carrying Out the Invention

Embodiments of the present invention will be specifically described with reference to drawings accompanying herewith.

(First embodiment)

Assuming that mobile stations that transmit

interference signals exist in the directions serving as null points of radiation patterns with respect to a mobile station to which the directivity is formed already. In other words, it can be considered that other mobile stations exist in the directions serving as a null point. Hence, according to the embodiment of the present invention, the null points of radiation patterns formed to the other mobile stations are detected to estimate the directions where the other mobile stations exist, generating weights to the mobile station to which the directivity is not formed yet so as to form radiation patterns using the weights as reception weights.

An explanation will be given of the array antenna radio communication apparatus and weight coefficient generating method according to the first embodiment of the present invention. FIG. 1 is a block diagram of main parts illustrating a general configuration of the array antenna radio communication apparatus according to the first embodiment of the present invention. It is noted that the array antenna radio communication apparatus illustrated in FIG. 1 is one that is normally provided in the base station. Hence, the following explanation is given on the assumption that communications between the mobile station and the array antenna radio communication apparatus are performed.

In FIG. 1, each of mobile stations 101-1 to 101-3

is the mobile station that performs communications with the array antenna radio communication apparatus. A radio section 103 provides predetermined radio processing to signals received via antennas 102-1 to 102-3. Demodulators 104-1 to 104-3 multiply received signals by spread codes assigned to the mobile stations 101-1 to 101-3, respectively, and provide demodulation processing to the received signals for each antenna. Reception weight generators 105-1 to 105-3 provide adaptive signal processing to the demodulated signals for each antenna, thereby generating reception weights. Radiation pattern generators 106-1 to 106-3 generate radiation patterns using generated reception weights.

A control section 107 controls reception weights based on radiation patterns already formed. Null detectors 108-1 to 108-3 detect the null-point directions of the respective radiation patterns formed to the mobile stations 101-1 to 101-3. Then, they output information (hereinafter referred to as "null information"), indicative of detected null-point directions, to a notifying section 109. The notifying section 109 notifies estimators 110-1 to 110-3 of all null information. The estimators 110-1 to 110-3 estimate the directions where mobile stations that cause interference with the respective mobile stations 101-1 to 101-3 exist, and generate

reception weights such that the respective null points are directed to the estimated directions using null information. The generated reception weights are used as initial values of reception weights at the reception weight generators 105-1 to 105-3, respectively.

An explanation will be next given of the actions of the array antenna radio communication apparatus having the aforementioned configuration. FIGS. 2A and 2B are views each illustrating a state that radiation patterns are formed by the array antenna radio communication apparatus according to the first embodiment of the present invention.

Herein, assuming that directivity is already formed as illustrated in radiation patterns 201 and 202 regarding the mobile stations 101-1 and 101-2. Also, supposing that directivity has not been formed yet as illustrated in a radiation pattern 203-A regarding the mobile stations 101-3.

First, the null detector 108-1 detects the null-point direction of the radiation pattern 201 generated by the radiation pattern generator 106-1. More specifically, the null detector 108-1 detects 0. and 135. as null-point directions, and outputs them to the notifying section 109 as null information 1.

Further, the null detector 108-2 detects the null-point direction of the radiation pattern 202

generated by the radiation pattern generator 106-2. More specifically, the null detector 108-2 detects -105. and 135. as null-point directions, and outputs them to the notifying section 109 as null information 2.

In addition, the null detector 108-3 cannot detect the null-point direction from the radiation pattern 203-A generated by the radiation pattern generator 106-3. Hence, the null detector 108-3 outputs information, indicating impossibility of detection, to the notifying section 109.

The notifying section 109 judges that directivity relating to the mobile station 101-3 has not yet been formed based on information indicating impossibility of detection. Then, the notifying section 109 outputs null information 1 and null information 2 to the estimator 110-3 corresponding to the mobile station 101-3.

The estimator 110-3 estimates the directions where the mobile stations 101-1 and 101-2, each causing interference with the mobile station 101-3, exist in the following way.

Namely, the estimator 110-3 estimates that there is the mobile station 101-2 or mobile station 101-3 that causes interference with the mobile station 101-1 in the direction of 0. or 135. based on null information 1.

Also, the estimator 110-3 estimates that there

is the mobile station 101-1 or mobile station 101-3 that causes interference with the mobile station 101-2 in the directions of -105. or 135. based on null information 2.

After that, the estimator 110-3 estimates that there is the mobile station 101-3 in the direction of 135. where all null points lie on upon another based on comparison between null information 1 and null information 2. The estimator 110-3 also estimates that there is the mobile station 101-1 or mobile station 101-2 that causes interference with the mobile station 101-3 in the directions where null points are formed except the direction of 135 . ,namely ,-105. and 0. .

Then, the estimator 110-3 generates a reception weight such that the radiation pattern indicated by 203-B is formed, that is, the radiation pattern where the nulls are directed to the directions of -105 . and 0. and a beam is directed to the direction of 135 . based on the estimation result. The estimator 110-3 outputs the generated reception weight to the reception weight generator 105-3 as an initial value of reception weight. The reception weight generator 105-3 sequentially updates the reception weight using the reception weight generated by the estimator 110-3 as an initial value.

Additionally, as an algorithm that is used to generate the reception weight, there is an adaptive

array with directional constraint (DCMP adaptive array) that can form a radiation pattern which directs the beam to the direction where a desired mobile station exists and which directs the null to the direction where a mobile station that causes interference exists.

Thus, according to the array antenna radio communication apparatus and the weight coefficient generating method of this embodiment, the null points of the radiation patterns formed to the other mobile stations are detected to estimate the directions where the other mobile stations exist, whereby generating a weight with respect to the mobile station to which the directivity is not formed yet and forming a radiation pattern using the weight as a reception weight. This makes it possible to form directivity with high accuracy in a short time with respect to the mobile station to which the directivity is not formed yet.

(Second embodiment)

In the array antenna radio communication apparatus and the weight coefficients generating method according to this embodiment, the reception quality in the case of using the radiation pattern, which is already formed, is compared with the reception quality in the case of not using the radiation pattern, which is already formed. Whereby,

a weight with respect to the mobile station to which the directivity is not formed yet is generated, and the radiation pattern is formed using the weight as a reception weight.

In the first embodiment, since the radiation patterns of the mobile station 101-1 and the mobile station 101-2 are formed, the radiation pattern of the mobile station 101-3 can be formed. However, in the case where the radiation pattern of the mobile station 101-1 or the mobile station 101-2 is not formed, the radiation pattern of the mobile station 101-3 cannot be formed in the first embodiment.

Now, for example, supposing that the radiation pattern of the mobile station 101-2 is not formed. The radiation pattern of the mobile station 101-3 must be formed using only null information 1 because no null information 2 exists. However, it is impossible to estimate in which of directions 0. and 135. the mobile station 101-2 exists by use of only null information 1. For this reason, it is impossible to judge in which direction the null point should be formed regarding the radiation pattern of the mobile station 101-3.

Hence, according to this embodiment, the reception quality using the radiation pattern of the mobile station 101-1, which is already formed, is compared with the reception quality using no radiation pattern of the mobile station 101-1, which

is already formed, thereby forming the radiation pattern to the mobile station 101-3 to which the directivity is not formed yet.

FIG. 3 is a block diagram of main parts illustrating a general configuration of an array antenna radio communication apparatus according to the second embodiment of the present invention. In addition, some portions in this embodiment are assigned the same symbols as those of corresponding portions in the first embodiment and its explanation is omitted.

Comparators 301-1 to 301-3 compare the reception qualities of received signals multiplied in the reception weight generators 105-1 to 105-3 by initial values of reception weights estimated by the estimators 302-1 to 302-3 with the reception qualities of received signals to which such multiplication is not performed, respectively. Herein, the reception quality refers to SIR of received signals or reception power etc.

An explanation will be next given of the actions of the array antenna radio communication apparatus having the aforementioned configuration. Herein, supposing that only the radiation pattern of the mobile station 101-1 is already formed and that the radiation pattern of the mobile station 101-3 is formed based on this radiation pattern.

The notifying section 109 outputs null

information 1 to the estimator 302-3 corresponding to the mobile station 101-3. The estimator 302-3 generates a reception weight such that the radiation pattern is formed where the null points are formed in the same directions as the directions of null points (0. and 135.) indicated by null information 1, and outputs the generated reception weight to the reception weight generator 105-3 as an initial value of the reception weight.

The reception weight generator 105-3 outputs a signal obtained by multiplying the received signal by the initial value of the reception weight and a signal which is not subjected to the multiplication to the comparator 301-3. The comparator 301-3 measures the reception quality of the signal obtained by multiplying the received signal by the initial value of the reception weight and the reception quality of the signal which is not subjected to the multiplication to compare. Then, the comparator 301-3 sends the comparison result to the estimator 302-3.

In the case where the reception quality of the signal obtained by multiplying the received signal by the initial value of the reception weight is better than the reception quality of the signal which is not subjected to the multiplication, the estimator 302-3 judges that there is a mobile station that causes interference with the mobile station 101-3

in the direction where the null point is formed, and outputs the initial value of the reception weight to the reception weight generator 105-3 without updating it.

While, in the case where the reception quality of the signal obtained by multiplying the received signal by the initial value of the reception weight is poorer than the reception quality of the signal which is not subjected to the multiplication, the estimator 302-3 judges that there is the mobile station 101-3 as a target of directivity to be formed in the direction where the null point has been formed. Then, the estimator 302-3 newly generates a reception weight such that the radiation pattern is formed where the null points are formed in the directions other than the directions (0. and 135.) indicated by null information 1, and outputs the newly generated reception weight as an updated initial value of reception value to the reception weight generator 105-3.

Now, herein, the case in which the reception quality of the signal obtained by multiplying the received signal by the initial value of the reception weight is better than the reception quality of the signal which is not subjected to the multiplication is as follows. Namely, SIR or reception power of the multiplied signal is higher than that of the non-multiplied signal. The case in which the

reception quality of the signal obtained by multiplying the received signal by the initial value of the reception weight is poorer than the reception quality of the signal which is not subjected to the multiplication is as follows. Namely, SIR or reception power of the multiplied signal is below that of the non-multiplied signal.

Additionally, in the case where weight control is performed using the algorithm of MMSE standard, an error between the received signal and a reference signal may be used in place of SIR or reception power to make it possible to carry out the aforementioned judgment in accordance with the value of the error.

Thus, according to the array antenna radio communication apparatus and the weight coefficients generating method of this embodiment, the reception quality in the case of using the radiation pattern, which is already formed, is compared with the reception quality in the case of not using the radiation pattern, which is already formed. Whereby, a weight with respect to the mobile station to which the directivity is not formed yet is generated, and the radiation pattern is formed using the weight as a reception weight. This makes it possible to form directivity having high accuracy in a short time with respect to the mobile station to which the directivity is not formed yet even in the case where

a plurality of mobile stations to which the directivities are not formed yet exist.

(Third embodiment)

In the array antenna radio communication apparatus and the weight coefficients generating method according to this embodiment, transmission weights are generated using reception weights estimated from the radiation patterns of the other mobile stations.

FIG. 4 is a block diagram of main parts illustrating a general configuration of an array antenna radio communication apparatus according to the third embodiment of the present invention. In addition, some portions in this embodiment are assigned the same symbols as those of corresponding portions in the first embodiment and its explanation is omitted.

Transmission weight generators 401-1 to 401-3 generate transmission weights using initial values of reception weights generated by the estimators 110-1 to 110-3. Weight multipliers 402-1 to 402-3 multiply transmission signals by the transmission weights, respectively. Modulators 403-1 to 403-3 multiply the transmission signals by spread codes to provide predetermined modulation processing to the transmission signals. The radio section 103 provides predetermined radio processing to the

modulated transmission signals and transmits them to the mobile stations 101-1 to 101-3 via the antennas 102-1 to 102-3.

An explanation will be next given of the actions of the array antenna radio communication apparatus having the aforementioned configuration.

The estimator 110-3 generates a reception weight such that the radiation pattern indicated by 203-B of FIG.2B is formed, that is, the radiation pattern where the null points are formed in the directions of -105. and 0. and the directivity is formed in the direction of 135. based on the estimation result. The estimator 110-3 outputs the reception weight to the transmission weight generator 401-3.

The transmission weight generator 401-3 generates a transmission weight using the reception weight with consideration given to a frequency difference of transmission and reception. The weight multiplier 402-3 multiplies the transmission signal by the generated transmission weight. Whereby, the transmission signal provided with the directivity is transmitted from the radio section 103 via antennas 102-1 to 102-3.

Thus, according to the array antenna radio communication apparatus and the weight coefficients generating method of this embodiment, the transmission weight is generated using the reception

weight estimated based on the radiation patterns of the other mobile stations. This makes it possible to transmit a signal to the mobile station on which has not been generated the reception weight yet with the directivity that does not cause interference with the other mobile stations.

In addition, the aforementioned first to third embodiments may be suitably combined and carried out.

As explained above, according to the present invention, it is possible to form directivity with an excellent convergence to the mobile station to which the directivity is not formed yet.

The application is based on the Japanese Patent Application No. HEI 11-299051 filed on October 21, 1999, entire content of which expressly incorporated by reference herein.

Industrial Applicability

The present invention is applicable to a base station apparatus used in a mobile communication system.

CLAIMS

1. A radio communication apparatus that forms a directivity using an array antenna composed of a plurality of antenna devices, said radio communication apparatus comprising:

a detector for detecting a null point of a radiation pattern for a communicating party to which a directivity is formed already;

an estimator for estimating a direction where the communicating party exists using the detected null point; and

a generator for generating a weight coefficient for a communicating party to which a directivity is not formed yet in accordance with an estimation result.

2. The radio communication apparatus according to claim 1, wherein said estimator performs a comparison of the null points of the radiation patterns for a plurality of communicating parties to which the directivities are formed already , and estimates that there is a communicating party that causes interference with a communicating party to which the directivity is not formed yet in a direction where the null point is not formed in any one of the radiation patterns, and said generator generates the weight coefficient by which the directivity is formed in the direction where the null point is not formed.

3. The radio communication apparatus according to claim 1, wherein said estimator estimates that there is a communicating party to which the directivity is not formed yet in a direction where the null points are formed in all radiation patterns of a plurality of communicating parties to which the directivities are formed already, and said generator generates the weight coefficient by which the directivity is formed in the direction where the null points are formed.

4. The radio communication apparatus according to claim 1, further comprising a comparator for comparing a first reception quality in the case of using the weight coefficient by which the directivity has already formed with a second reception quality in the case of not using the weight coefficient, and said estimator estimates a direction where a communicating party exists in accordance with a comparison result.

5. The radio communication apparatus according to claim 4, wherein said estimator estimates that there is the communicating party that causes interference with the communicating party to which the directivity is not formed yet in the direction where the null point is formed when the first reception quality is better than the second reception quality, and said generator generates the weight coefficient such that the null point is formed in

the direction where the null point is formed.

6. The radio communication apparatus according to claim 4, wherein said estimator estimates that there is the communicating party to which the directivity is not formed yet in the direction where the null point is formed when the first reception quality is poorer than the second reception quality, and said generator generates a weight coefficient such that the directivity is formed in the direction where the null point is formed.

7. The radio communication apparatus according to claim 1, further comprising a transmission coefficient generator for generating a weight coefficient by which a transmission signal is multiplied using the weight coefficient generated by said generator.

8. A base station apparatus having a radio communication apparatus that forms a directivity using an array antenna composed of a plurality of antenna devices, said radio communication apparatus comprising:

a detector for detecting a null point of a radiation pattern for a communicating party to which a directivity is formed already;

an estimator for estimating a direction where the communicating party exists using the detected null point; and

a generator for generating a weight coefficient

for a communicating party to which a directivity is not formed yet in accordance with an estimation result.

9. A weight coefficient generating method comprising the steps of:

detecting a null point of a radiation pattern for a communicating party to which a directivity is formed already;

estimating a direction where the communicating party exists using the detected null point; and

generating a weight coefficient for a communicating party to which a directivity is not formed yet in accordance with an estimation result.

ABSTRACT

Null detectors 108-1 to 108-3 detect the directions of null points of the respective radiation patterns formed for mobile stations 101-1 to 101-3 and output information indicative of detected null-point directions to notifying section 109, notifying section 109 notifies estimators 110-1 to 110-3 of all null information, and estimators 110-1 to 110-3 estimate the directions where mobile stations that cause interference with the respective stations 101-1 to 101-3 exist, and generate reception weights using null information.

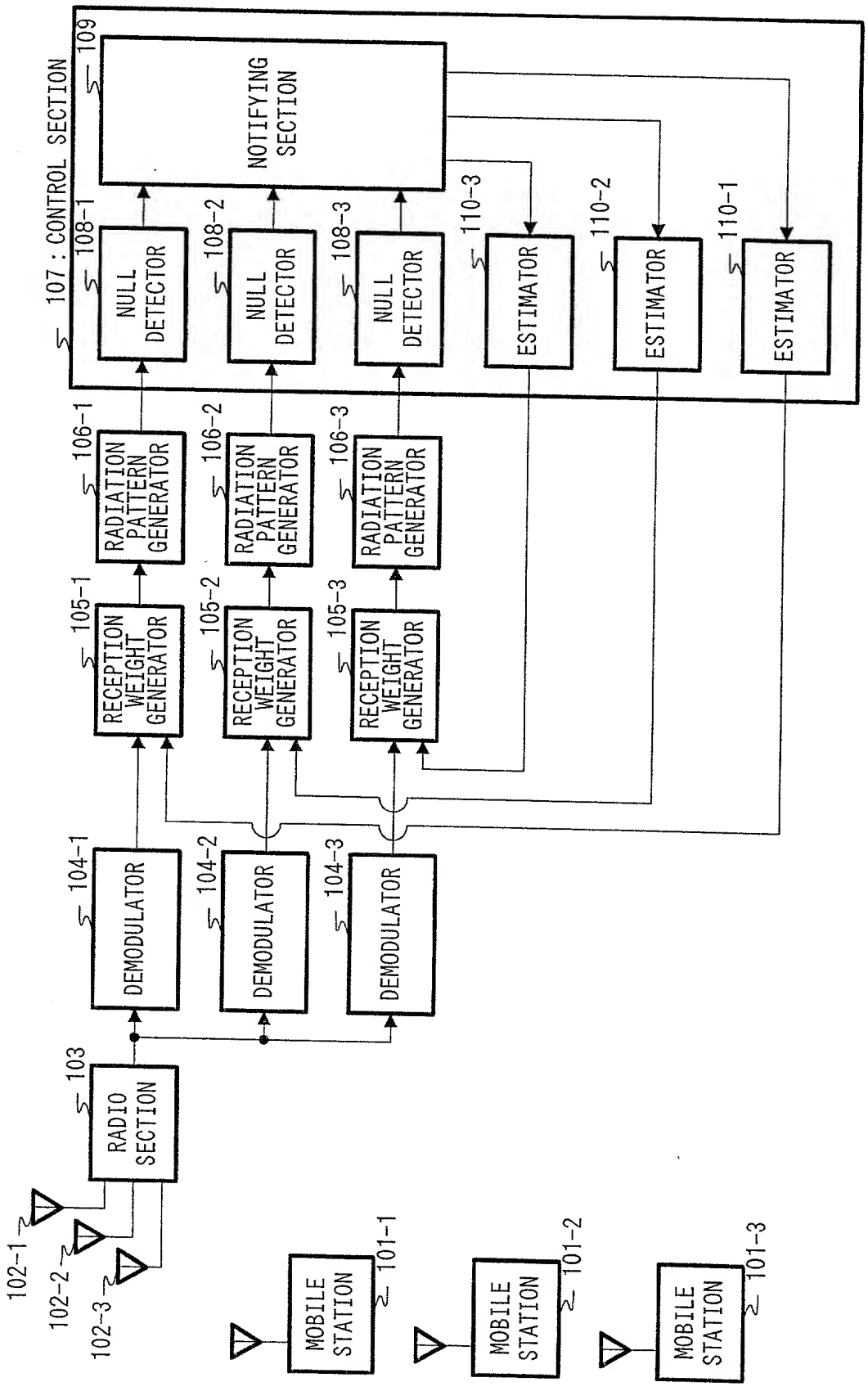
MOBILE STATION 101-1
MOBILE STATION 101-2
MOBILE STATION 101-3
102-1
102-2
102-3
RADIO SECTION 103
DEMODULATOR 104-1
DEMODULATOR 104-2
DEMODULATOR 104-3
RECEPTION WEIGHT GENERATOR 105-1
RECEPTION WEIGHT GENERATOR 105-2
RECEPTION WEIGHT GENERATOR 105-3
RADIATION PATTERN GENERATOR 106-1
RADIATION PATTERN GENERATOR 106-2
RADIATION PATTERN GENERATOR 106-3
107 : CONTROL SECTION
NULL DETECTOR 108-1
NULL DETECTOR 108-2
NULL DETECTOR 108-3
NOTIFYING SECTION 109
ESTIMATOR 110-1
ESTIMATOR 110-2
ESTIMATOR 110-3

FIG. 1

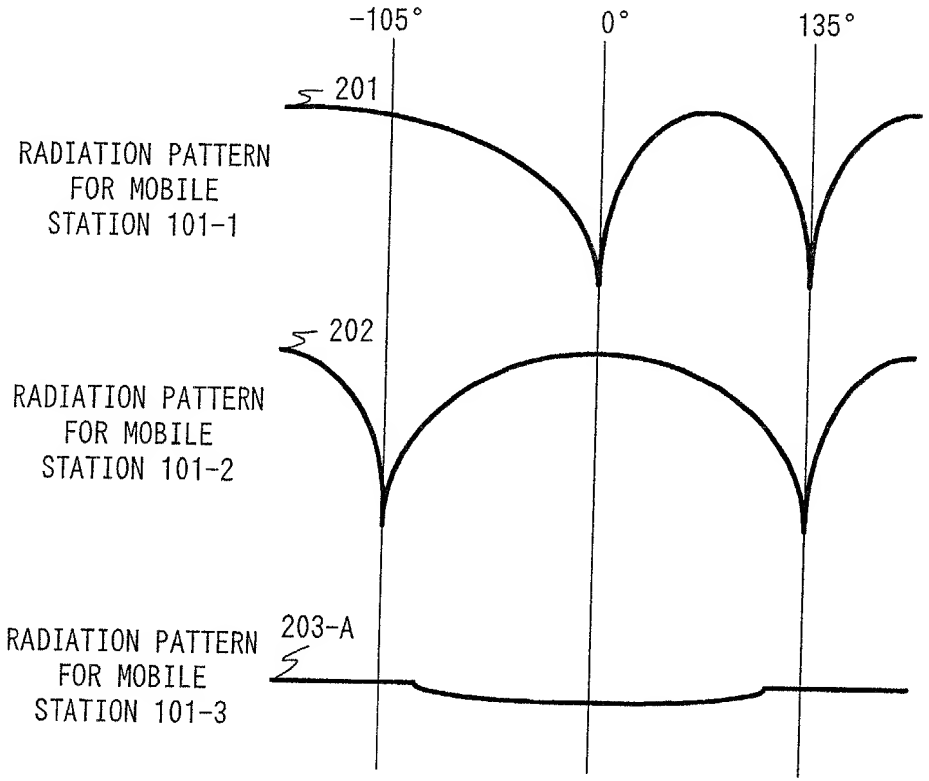

FIG. 2A

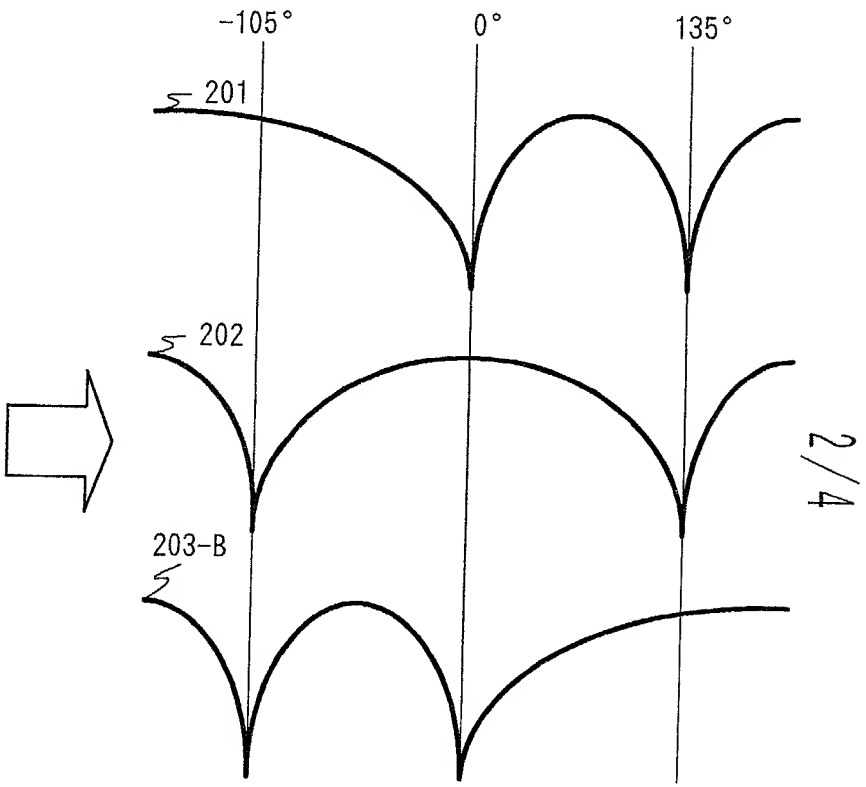

FIG. 2B

09/868898/60

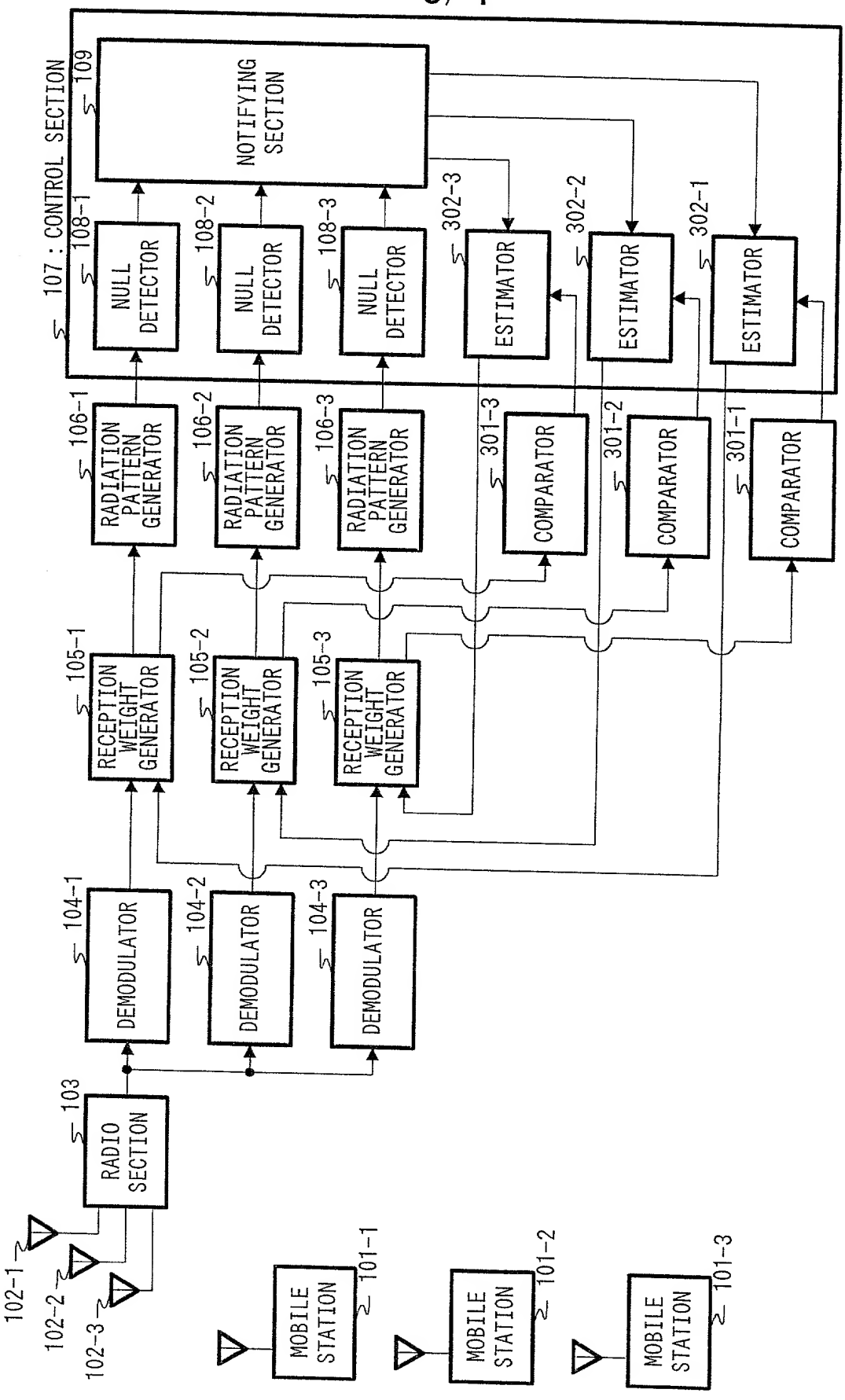
MOBILE STATION
101-1
MOBILE STATION
101-2
MOBILE STATION
101-3
102-1
102-2
102-3
RADIO SECTION
103
DEMODULATOR
104-1
DEMODULATOR
104-2
DEMODULATOR
104-3
RECEPTION WEIGHT GENERATOR
105-1
RECEPTION WEIGHT GENERATOR
105-2
RECEPTION WEIGHT GENERATOR
105-3
RADIATION PATTERN GENERATOR
106-1
RADIATION PATTERN GENERATOR
106-2
RADIATION PATTERN GENERATOR
106-3
107 : CONTROL SECTION
NULL DETECTOR
108-1
NULL DETECTOR
108-2
NULL DETECTOR
108-3
NOTIFYING SECTION
109
COMPARATOR
301-1
COMPARATOR
301-2
COMPARATOR
301-3
ESTIMATOR
302-1
ESTIMATOR
302-2
ESTIMATOR
302-3

FIG. 3

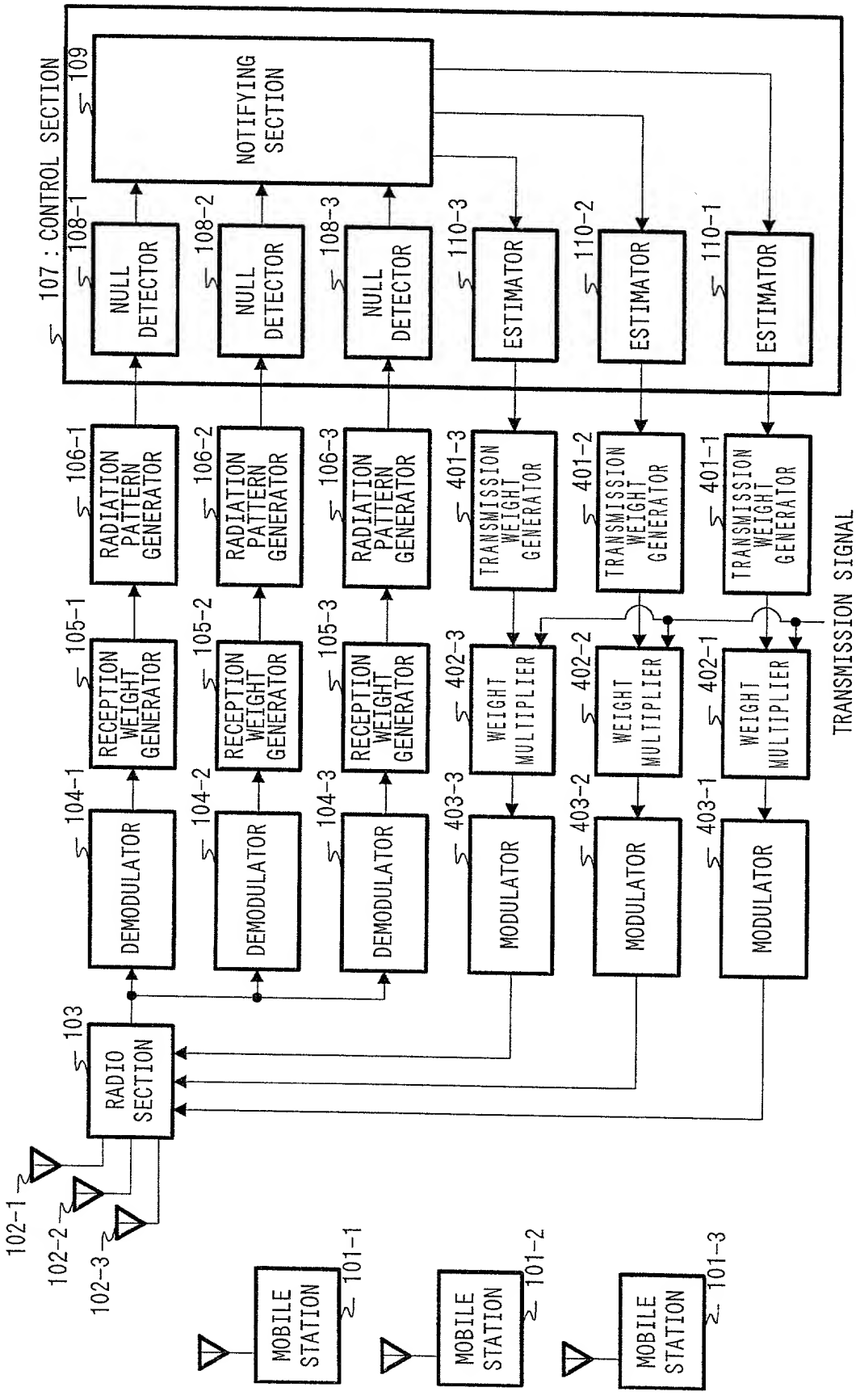
107 : CONTROL SECTION
109
NOTIFYING SECTION
108-1
NULL DETECTOR
108-2
NULL DETECTOR
108-3
NULL DETECTOR
110-3
ESTIMATOR
110-2
ESTIMATOR
110-1
ESTIMATOR
106-1
RADIATION PATTERN GENERATOR
106-2
RADIATION PATTERN GENERATOR
106-3
RADIATION PATTERN GENERATOR
401-3
TRANSMISSION WEIGHT GENERATOR
401-2
TRANSMISSION WEIGHT GENERATOR
401-1
TRANSMISSION WEIGHT GENERATOR
105-1
RECEPTION WEIGHT GENERATOR
105-2
RECEPTION WEIGHT GENERATOR
105-3
RECEPTION WEIGHT GENERATOR
402-3
WEIGHT MULTIPLIER
402-2
WEIGHT MULTIPLIER
402-1
WEIGHT MULTIPLIER
104-1
DEMODULATOR
104-2
DEMODULATOR
104-3
DEMODULATOR
403-3
MODULATOR
403-2
MODULATOR
403-1
MODULATOR
TRANSMISSION SIGNAL
103
RADIO SECTION
102-1
102-2
102-3
MOBILE STATION
101-1
MOBILE STATION
101-2
MOBILE STATION
101-3

FIG. 4

APPLICATION FOR UNITED STATES PATENT
Declaration for Patent Application

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on

the invention entitled: ARRAY ANTENNA RADIO COMMUNICATION APPARATUS AND WEIGHT COEFFICIENT GENERATING METHOD

the specification of which
(check at least one)
2 (file no _____)
3 [x] is attached hereto
4 [ ] was filed on _____ as (5) U.S. Application Serial No. _____
6 [ ] and was amended _____ (if applicable)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application designating the U.S.

7 [ ] was filed as PCT international application
8 Number PCT/JP00/07263 ✓
9 on October 19, 2000 ✓
and was amended under PCT Article(s) 19 and/or 34
10 on _____ (if applicable).

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application (s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed.

Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119

	(Country)	(Number)	(Day/Month/Year Filed)	Priority Claimed	
11a	Japan ✓	H11-299051 ✓	21/October/1999 ✓	[X] Yes	[ ] No
				[ ] Yes	[ ] No

[ ] Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

Priority Claim(s) from U.S. Provisional Application(s) – I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

11b	Application No.	Day/Month/Year Filed	Application No.	Day/Month/Year Filed

Do not use this portion to identify a PCT application if the parent application is the U.S. National phase of the PCT application

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application.

13	(U.S. Application Number)	(U.S. Filing Date)	Status (patented, pending, abandoned)

I hereby appoint the following attorneys of the firm of Stevens, Davis, Miller & Mosher, L.L.P. as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office:

James E. Ledbetter, Reg. No. 28732; Thomas P. Pavelko, Reg. No. 31689; and Anthony P. Venturino, Reg. No. 31674.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO STEVENS, DAVIS, MILLER & MOSHER, L.L.P., 1615 L Street, N.W., Suite 850, Washington, D.C. 20036, TELEPHONE (202) 408-5100, FACSIMILE (202) 408-5200.

See page 2 for signature lines

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other side for instructions for completing this form

INSTRUCTIONS FOR COMPLETION OF THIS FORM

line 1 Insert the same title as is used on the specification and in the assignment.

line 2 Is optional but is provided so that you can use it to identify more readily an application prior to the time that the Patent Office application serial number is assigned. We suggest that the specification, drawings and declaration always bear a file number since it can help to get the papers together in case they become inadvertently separated. In instances where the specification is filed without a signed declaration form (under 37 CFR §1.53) a file number on a later-received separate form will assist us in associating it with the correct case.

line 3 Check this box if the specification, claims and drawing (if any) are attached to this declaration form, e.g., when filing a new patent application.

lines 4-5 Are only used in an instance where the application is already on file and the declaration from is being separately filed, e.g.,when the application was originally filed without a signed declaration or where the Patent Office has required a new declaration because of a deficiency in the original declaration. In such an instance the Patent Office will require that lines 4 and 5 be completed with the filing date and application serial number already assigned.

line 6 Is used in conjunction with line 5 but only when there have been one or more amendments to the specification or claims. Line 6 is also used when the Examiner requires a new declaration because claims inserted by amendment cover subject matter not originally claimed (37 CFR §1.67).

lines 7-10 Are for PCT (Patent Cooperation Treaty) cases and are used only when you are entering the U.S. National phase (Chapter I or II) based upon a previously filed PCT International application designating the U.S.

line 7 Check this box if this is a PCT National Phase application.

line 8 Insert PCT International application number.

line 9 Insert date of filing of PCT International application.

lines 10 Insert the date of all amendments filed in the PCT International application. Such amendments are optional, so this line at times will not be used.

line 11a Is used in the following instances:

(i) If a single priority is being claimed from a foreign application you need to list only the first-filed application; you do not need to list other countries if all applications were filed within one year of the U.S. filing.

(ii) If multiple priorities are being claimed, from a plurality of applications filed in one or more countries, you must list the first filed application for each aspect of the invention. Example: if aspect A of the invention was disclosed in an application filed 11 months earlier in country X and aspect B was disclosed 9 months earlier in an application filed in country Y, then the applications in both countries X and Y must be identified. Only the first application for each aspect of the invention needs to be identified provided all applications on that aspect were filed within one year prior to the U.S. filing.

(iii) If a non-priority application is being filed you must list all applications in all countries where corresponding foreign applications were filed more than one year prior to the U.S. filing. This is so the Examiner can check to see if any of those applications were published or patented early enough to be prior art against the U.S. application.

(iv) If there are more than two applications to be listed we suggest that you type in on this form only "See attached Schedule A" and then list all of the previous applications on an attached sheet.

line 11b Is used to claim priority under 35 USC §119(e) based on a provisional application filed within one year of the filing of the instant application. More than one provisional application may be identified provided neither was filed more than one year earlier.

line 12 This block is used only in instances where there is a previously filed U.S. non-provisional application which was copending at the time the present application was (or is being) filed. that previous application could be a U.S. non-provisional application or the National Phase of a PCT allocation. In such a case the present application may be entitled to the priority of the previous application's U.S. filing date (and consequently the foreign priority thereof) provided the present application is identified as a continuing application (continuation, divisional or continuation-in-part) of the earlier (parent) application. If the foregoing is applicable, please fill in one line for each such prior application.

line 13 Type the inventor's proper legal name in the order specified, e.g., "John B. JONES" or "J. Bob JONES" if the inventor so prefers. It is not acceptable to use only initials such as "J. B. JONES."

line 14 The inventor's "signature" may be his (or her) usual manner of signing but it is preferable that the inventor simply write his (or her) name in his (or her) own cursive handwriting in the same order as on line 14, e.g., given name, middle initial and Family name.

line 15 Insert the actual date of signature.

line 16 Insert simply the city and state or country, e.g., "Paris, France", of the inventor's residence, not citizenship. No street address or postal code is required on this line.

line 17 Insert the inventor's citizenship. The statement of citizenship (or subject of) is a statutory requirement (35 USC §115). Simply the name of the country of citizenship, e.g., "Japan" is sufficient.

line 18 Insert the inventor's mailing address. The purpose of requiring the post office address is to enable the Patent Office to communicate directly with the inventor if desired, such as in the case of death of the U.S. attorney. It should be the address where the inventor customarily receives his (or her) mail and should include the postal code. If applicable it can be the inventor's business address or address at place of employment.

Applicants are reminded that the U.S. Patent and Trademark Office has very strict requirements as to proper execution of an application. The applicant should make sure that he reviews the declaration, prior to signing to make sure the declaration properly identifies the application and all relevant information; and should review the specification and claims (including drawings, if any) before signing the declaration. Failure to do so will require the filing of a supplemental declaration --- 37 CFR §1.67(c).

Any handwritten changes to the specification, claims or drawings must be in ink personally by all of the inventors prior to signing the declaration and the adjacent left margin must be initialed and dated by all of the inventors, e.g., "JBJ 6-9-91".

Please let us know if there are any questions regarding proper completion of this form. Thank you.

An assignment, a separate document requiring separate signature and dating may be enclosed. Please look for it and sign and date it in the same manner as in lines 15 and 16 above.

STEVENS, DAVIS, MILLER & MOSHER, L.L.P.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

13a	Typewritten Full Name of Sole or First Inventor	**Takahisa**		**AOYAMA**	
		Given Name	Middle Name	Family Name	
14a	Inventor's Signature	Takahisa Aoyama			
15a	Date of Signature	May	25,	2001	
		Month	Day	Year	
16a	Residence	**Yokosuka-shi**	**Kanagawa**		**JAPAN**
		City	State or Province		Country
17a	Citizenship	**JAPAN**			
18a	Post Office Address *(Insert complete mailing address, including country)*	**2-25-1-102, Nobi,**			
		Yokosuka-shi, Kanagawa 239-0841 JAPAN			
13b	Typewritten Full Name of Sole or First Inventor				
		Given Name	Middle Name	Family Name	
14b	Inventor's Signature				
15b	Date of Signature				
		Month	Day	Year	
16b	Residence				
		City	State or Province		Country
17b	Citizenship				
18b	Post Office Address *(Insert complete mailing address, including country)*				
13c	Typewritten Full Name of Sole or First Inventor				
		Given Name	Middle Name	Family Name	
14c	Inventor's Signature				
15c	Date of Signature				
		Month	Day	Year	
16c	Residence				
		City	State or Province		Country
17c	Citizenship				
18c	Post Office Address *(Insert complete mailing address, including country)*				
13d	Typewritten Full Name of Sole or First Inventor				
		Given Name	Middle Name	Family Name	
14d	Inventor's Signature				
15d	Date of Signature				
		Month	Day	Year	
16d	Residence				
		City	State or Province		Country
17d	Citizenship				
18d	Post Office Address *(Insert complete mailing address, including country)*				

*Note to Inventor: Please sign name on line 15 exactly as it appears in line 14 and insert the actual date of signing on line 16. If there are more than four inventors, please add a copy of this page for identification and signatures for the additional inventors.

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